University of Cambridge
School of Agriculture Memoirs

Memoir No. 24

A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Organisations during the period Oct. 1st, 1951—Sept. 30th, 1952.

Review Series

No. 7. Field Drainage Work at Cambridge, 1930—1952.

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FOREWORD

This Memoir, which is published under the general editorship of the Librarian of the School, represents an attempt to present as succinctly as possible the contributions made by members of the Staffs of the School of Agriculture and its Associated Research Organisations to the development and progress of Agricultural Science, to indicate to research workers interested the Journals in which the full papers are presented and to act as a complete record of papers published. Each summary is compiled by the author of the paper and is presented, so far as the subject matter will allow, in a non-technical form in order to be of value to the general body of farmers interested in the more recent developments of agricultural scientific research in general and of the activities of this Department in particular.

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FIELD DRAINAGE WORK AT CAMBRIDGE 1930-52*

By

H. H. NICHOLSON, M.B.E., M.A.

(*University Reader in Soil Science*)

For several generations prior to 1930 there had been little, if any, investigational work on field drainage in this country; indeed, the practice itself in many districts had lapsed into oblivion. Nevertheless, it continued to be described, both in discussion and in the textbooks as a fundamental requisite for fertility and high production. Existing knowledge was mostly derived from local practice and the recorded experience and views of a number of well-known drainage engineers of a hundred or more years ago, such men as Josiah Elkington of Princethorpe, James Smith of Deanston, Josiah Parkes of Chat Moss fame and James Bailey Denton, who left the only account of a serious experiment with sustained observations, and the recording of results, that remains to us, which experiment incidentally was carried out not so very far away—at Hinxworth, Herts. Subsequent to this, the lysimeter experiments at Rothamsted were the main source of information on percolation through the soil, and the only ones with a direct bearing on drainage problems.

Such was not the case abroad, however. The science of land improvement, known as *Kulturtechnik*, had been developing on the Continent since early in the present century, and after the First World War it was pursued with vigour in Germany, Holland, Poland and Czechoslovakia amongst others, especially in respect of the control of ground water in mineral soils of appreciable permeability. In the United States, important work on the movement of soil moisture, the study of ground water levels and the performance of field drains had been in progress since the nineties. The subject was outlined and reviewed by J. L. Russell (1).

The inception of work on drainage in the School of Agriculture was due to Professor Sir Frank Engledow. In a memorandum in 1931 he wrote: " In the country at large one of the greatest possibilities of increasing soil productivity is by improved drainage. Cleaning of rivers and open drains, restoring tile drains, re-cutting moles and other work of renovation would be highly advantageous. Except on the heaviest soils well understood methods can in general be applied and drainage reform calls for political and administrative action rather than research. Such action lies at present beyond the scope of research stations although these may in time find responsibilities in connection with the geological and topographical aspects of the subject. Heavy clays, amounting in the Eastern Counties to nearly half a million acres, present drainage problems of many kinds. Some of these cannot be dealt with by existing methods and there is a big field for research involving, among other things, problems of water holding capacity and connected questions of colloidal physics. On such land lack of drainage is the major limiting factor to plant development and yield whether of ploughland or grass. . . . Few agricultural questions are so costly or scientifically so difficult as those of drainage, and few have been so scantily studied. In these circumstances the correct policy appears to be to attack the broad agricultural problem first, to employ empirical methods as long as they will serve; and to identify, and evolve our experiments gradually towards, the scientific questions into which the broad practical problem resolves itself. Past studies of drainage, apart from the work of the pioneers, have proceeded from the policy of studying patent and interesting scientific aspects, e.g., imbibitional power of soil colloids, without special reference to the main practical problem. The main agricultural question for us may be thus propounded " Is it possible to drain heavy clay land in such a way that the advantage to cultivation and to plant environment ensures an economic return ? ". . . . While many heavy fields are declared to be ' better ' after draining, the nature of the betterment cannot be clearly described nor measured. . . . Unless the exact nature of improvement be understood they can never be fully exploited or much developed."

It was the depressed state and natural physical disabilities of the Eastern Counties clay land which constituted a challenging problem. The administrative county of Cambridge in itself included clay land to the extent of 38% of its area, and it was a reconnaissance soil survey of this county which first produced a general picture of soil drainage conditions in this neighbourhood in terms of soil morphology, geology and topography (2). In the Eastern Province of that time, of an agricultural area of some 4½ million acres, 1,900,000 was heavy land on clay formations. Ideas on drainage conditions and practice on these considerable areas were given precision as a result of the surveys carried out by Carslaw in the Department of Agricultural Economics. He found that 26% of the clay land was in need of field draining (3–4).

In 1931, the University Farm had just taken over the Ladysmith land, then on the verge of dereliction, and it was natural and convenient that early work on clay land drainage should consist largely of the study of gault clay land and its moisture regime within the University Farm. Much valuable help was given by a succession of graduate students in Soil Science during the early 1930's. In particular R. K. Kirkham and J. Lamb made observations on the outfall performances of existing and new field drainage systems and developed the use of plaster casts as a means of studying the nature and decay of mole drains. R. H. Hamilton and C. W. Innes studied the soil profile morphology, space relationships and permeability of the gault clay soil. J. L. Russell studied the gault clay profile particularly in respect of the moisture content and its seasonal changes. This preliminary work produced a picture of clay soils whose drainage properties were dominated by their structure profile, in which free gravitational movement of water seemed to be confined to the topsoil or tilth layer, a matter of a few inches. The ground water was mainly superficial and wholly seasonal in its appearance. Field drain systems apparently functioned by virtue of the opening effect of digging the drain trenches in the case of intensive thorough draining by pipes, or of the opening and fissuring effect of the passage of the mole plough in its even more intensive fashion (5–6).

* *This is the seventh of a series of articles summarizing phases of agricultural research particularly associated with the School of Agriculture since its inception. Further contributions on other work will appear in future issues.*

The use of plaster casts threw a good deal of light on what the mole plough did. It revealed the shape of the channels *in situ* and the striking effects of the setting and handling of the mole plough thereon. The way in which they subsequently decayed under the influence of weathering and some of the reasons for their comparatively short life became manifest (7—8).

Meanwhile the laborious accumulation of outfall rates of a number of well defined drainage systems on the farm, by means of a stop watch and roughly calibrated receptacles, and a study of them in conjunction with the published records of J. Bailey Denton at Hinxworth in 1856, produced a comparable picture of the drain performance of different systems working in close and open soils. The anomalous behaviour of test wells in clay land, relative to drain performance was noted and fitted into the general picture. The nature of the seasonal changes in run-off and the effect of variations in the cultivational treatment of land also came under observation (9). The accumulation of data of drain runs and of the moisture content of gault clay soils in the 1930's gave an increasingly accurate measure of the importance of their moisture holding capacity, and were destined to be of considerable interest years later to meteorologists and others in their study of trafficability of soils during the war and work on moisture deficits in soil in the summer months and its significance in problems of irrigation and water supply.

It early became apparent that further prosecution of the research constituted an essay into the field of soil physics, and E. C. Childs was appointed to conduct it. With a view of further investigating the heavy land drainage problem, it was desired to initiate field experiments on mole drainage, and one point which seemed to offer possibilities as a basis of comparison was that of outfall performance, if it could be recorded in a sufficiently accurate and detailed fashion. Childs evolved a simple compact meter in which a revolving chart recorded the rise and fall of a float in a chamber receiving the efflux from a drain, and emptying it via a diaphragm perforated in such a fashion that the flow was directly proportional to the depth of water in the chamber (10). A field experiment was started at Fenstanton in 1939 and was kept going against increasing difficulties throughout the War. Childs found it confirmed the ideas on heavy land drainage which had already materialised, especially the surface nature of the run-off. Thus it became apparent that quite a slight ridge such as existed by reason of the barely perceptible ridge and furrow surface of the field, served to isolate one plot from the next, while a single catchwater furrow effectively protected the experimental area from the entry of foreign water on its high side. The outfall records showed that during the drainage season the moles began to run very soon after the commencement of a heavy shower but, in the case of a drizzle, hours might elapse before the flow began. Once it had started, the outfall rate reflected the rainfall closely and quickly. The record was one of sharp peaks of activity separated by equally sharp troughs. At the beginning of a period of rain the soil is able to absorb water at a high rate, but its power to do so steadily falls ; as soon as it is less than the rate of incidence, drainage begins. Cessation of rain is followed by the recovery of the power of the soil to absorb water, to an appreciable extent even in 24 hours. As the mole drains got older, so the nature of their performance seemed to alter ; their response to rainfalls was slower. A run-off rate of as high as 1,500 gals. per acre per hour was recorded, while peaks of 750 were frequent. These facts are important relative to the desirable size of mains to be provided in draining (11).

The need to be able to assess the suitability of a soil to mole draining led Childs to make use of ' the soil moisture characteristic ' obtained by plotting the moisture content of soil against the suction with which it is held, as a means of studying this aspect of moling. Interpreting it as an expression of pore size distribution in the soil, he was able to study the state of aggregation in a soil and the stability of the aggregates, and thus to throw light on the structure profile of different clay soils, the stability of specific types of clay, the conditions at moling depth, and the effect of successive cycles of wetting and drying. This work provided a means for an assessment of the possibilities of mole draining in clay land in districts where the practice was not common and for the investigation of failures of mole draining (12–13). The mole plough itself also came under Childs's scrutiny. He investigated its mechanical principles, especially its conditions of equilibrium in action, the magnitude of the forces involved, and their significance in the setting of the mole plough. He demonstrated that the cartridge, if properly set, tends to maintain itself at its proper depth in spite of irregularities in the surface of the ground and that the value of the beam lies in its length, which gives full play to the self-adjusting forces of the cartridge (14–15).

The drainage work of the School of Agriculture in the 1930's and during the war played its part in the inception of the Land Fertility Scheme of 1937 and the prompt wartime measures taken to revive the practice of field draining (16–19). Much advisory work was done for the War Agricultural Executive Committees and the Air Ministry. Short courses were run for the benefit of land drainage officers, of whom some 200 attended in groups, and a series of leaflets on the practical aspects of the School's drainage investigations was produced and widely distributed (20).

Another line of work begun during the War arose out of the ever-present problem of Fen drainage. Both the Great Ouse Catchment Board and the local W.A.E.C. were anxious to obtain information on the effect of ground water level on crop production (21–22). Preliminary studies were begun in 1943, and gradually the nature of the problem, its context, and some factors of importance were elucidated to the extent that a field experiment was commenced in 1947 by Nicholson, with G. Alderman and later D. H. Firth. It was decided to set up a range of ground water levels and maintain them steady during the growing season, with a rotation of typical Fen crops over the whole range, and to carry the experiment on for a number of years, in order to accumulate records of performance against the background of seasonal variations in rainfall. The experiment is sited on a light peat soil (black Fen) at Burwell (Cambs.); it occupies some 14 acres, and the rotation is potatoes, rye, sugar beet, wheat, kale and celery (half-plots), and ryegrass; it is in its sixth year (23). Light has been thrown on the ground water regime of these Fen soils and the difficulties of controlling the ground water level infield are being appreciated together with the rôle of ditches and field drains. It was found that crops differed in their reaction to ground water conditions but that the seasonal incidence of rain had an over-riding

influence on their performance (24). Ground water level can influence the growth of a crop directly in its development or indirectly through weed infestation, cultivation difficulties or the incidence of disease. In dry seasons, high ground water levels, e.g., 20 ins., have benefited celery, potatoes, kale and sugar beet; but in wet seasons water levels higher than 20 ins. have caused the failure of sugar beet, kale and ryegrass and have depressed the yield of celery and potatoes; and evidence has been forthcoming of optimum ground water levels for these two last-named (25). A. Eden, G. Alderman and C. J. L. Baker by a detailed examination of the produce of the ryegrass through two seasons of this experiment have shown the deleterious effects on both quantity and quality of high ground-water levels and by contrast the markedly beneficial effects of ground water levels of the order of 24–36 ins. (26–27).

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AGRICULTURAL ECONOMICS

Costs and Returns in Pig Production, 1947-1951. Pp. 23.
Fm Econ. Br. Fmrs' Bull. No. 13, 1952. Price 1*s.* 6*d.* Post Free.

This report is the result of analysing four years' results of the Cambridge University Food Recording Scheme for Pigs, from 1947–1951. The first part deals with the whole sample, as a reflection of the changes that were taking place in the industry. The period concerned covers the great post-war expansion in pig production and shows that the years 1949 and 1950 were the times of greatest profit. In the last year this profit was falling sharply, a trend that has been continued since. The reasons for the rise and fall in profitability are analysed, and the effect of the differential price structure introduced in 1950 is examined.

In the second part of the report the structure of costs in the herds is considered in greater detail, and the breeding and fattening sections are treated separately. In addition to showing the actual level of costs, an attempt has been made to draw attention to certain critical factors in pig production, such as the number of pigs weaned per sow per annum and the level of the food conversion in terms of lbs. of meal per lb. liveweight increase. It is by attention to these points that farmers can most easily reduce costs, and in the face of rising prices greater emphasis will have to be placed on standards of management.

Economics of Green Crop Conservation, 1949 and 1950. Pp. 64.
Fm Econ. Br. Rep. No. 36, 1952. Price 6*s.* Post Free.

This report considers the economics of grass, clover and lucerne conservation in the Eastern Counties in 1949 and 1950. In both years a sample of farms which practised haymaking, ensiling and grass drying were investigated to discover relative costs of production and the quality of the feedingstuffs produced. The weather in 1949 differed from that in 1950 in that the latter year was much wetter and therefore growing conditions were better.

The cost of dried grass in 1949 ranged from £13 6*s.* to £34 12*s.* per ton and averaged £18 16*s.* per ton. In 1950 the range of costs was from £13 6*s.* to £34 14*s.* per ton with an average cost of £19 4*s.* per ton. Hay costs in 1949 ranged from £1 12*s.* 6*d.* to £10 14*s.* 0*d.* per ton and averaged £4 0*s.* 3*d.* per ton. In 1950 the cost of the hay investigated varied from £1 15*s.* 0*d.* to £9 8*s.* 9*d.* per ton and averaged £4 2*s.* 4*d.* per ton. Similarly, in 1949 the range of silage costs was from 13*s.* 6*d.* to £4 12*s.* 0*d.* per ton and the average cost was £1 14*s.* 6*d.* per ton. In 1950 the average cost of silage was £1 15*s.* 6*d.* per ton and the range was from 14*s.* 5*d.* to £6 4*s.* 8*d.* per ton.

The crude protein of dried grass expressed as a percentage of the dry matter was 17·84 in 1949 and 17·26 in 1950 ; that of hay was 12·10 and 13·97 respectively and that of silage was 15·71 and 16·02 respectively. In 1949, the production of starch equivalent per acre per annum was 2,944 lb. from ensiling, 1,804 lb. from drying and 974 lb. from haying. In 1950, the production of starch equivalent per acre per annum was 2,590 lb. from ensiling, 2,265 lb. from drying and 926 lb. from haying. This illustrates one of the benefits of cutting herbage for drying as frequently as possible. In 1949 herbage was cut twice, whereas in 1950 it was cut three times.

Protein and starch were produced cheaply by the hay and silage compared with the dried sample. A hundredweight of protein equivalent derived from the hay of the sample in 1949 cost 86*s.* 6*d.* compared with 70*s.* 3*d.* in 1950. The same weight derived from the silage sample cost 82*s.* 8*d.* in 1949 and 85*s.* 10*d.* in 1950. Similar figures from the sample of drying were 179*s.* 8*d.* in 1949 and 185*s.* 8*d.* in 1950. The cost of starch equivalent obtained by drying was about three times the cost of that obtained from hay and silage.

A comparison of conserved herbage and other feedingstuffs reveals the relative cheapness of the former ; the more so in 1950 when subsidies on imported foods had been reduced or removed. The tendency for world prices to rise will make home grown conserved feedingstuffs more attractive to the British farmer. There are good reasons to believe that grass and other green crops might contribute in large measure to a solution of the feedingstuff problem. The aim of conservation should be a quality product and undoubtedly this is obtainable so long as the herbage is cut in the early stages of growth.

Economics of Overhead Irrigation on an East Suffolk Farm. Pp. 6.
Fm Econ. Br. Misc. Publ. No. 1, 1952. Price 1*s.* Post Free.

The costs of this type of operation can be divided into two parts, fixed and variable. The fixed cost is made up of the depreciation charges on water mains, pumps etc. and does not vary in total with changes in the acreage irrigated. The variable costs cover the cost of water, moving spraylines and the energy required to pump the water onto the land. The share of fixed costs per acre will be lower as the acreage irrigated increases, but the variable cost remains the same. In 1950, 61 acres were irrigated to a depth of two inches for a total cost of £6 12*s.* 9*d.* per acre, and in 1951, 53½ acres were irrigated at the rate of 1¾ inches per acre for £6 5*s.* 2*d.* The total sum chargeable as fixed costs in each year was £272 10*s.* 0*d.*, and the variable costs per acre were £1 8*s.* 2*d.* in 1950 and £1 3*s.* 4*d.* in 1951.

A Survey of the Cost of Producing Wheat in Three Districts in the Eastern Counties, 1950.
Fm Econ. Br. Mimeog. Rep. No. 43, 1951.

A Survey of the Cost of Producing Sugar Beet in Three Districts in the Eastern Counties, 1950.
Fm Econ. Br. Mimeog. Rep. No. 44, 1951.

EASTWOOD, T.

Industry in the County Towns of Norfolk and Suffolk. Pp. 63.
Oxford Univ. Press, 1951. Price 6*s.*

SCOVILLE, O. J.

The Organisation and Productivity of Farm Labour.
Proc. 6th Oxford Fmg Conf. 1952, 20–31.

Comparisons of production per worker in different countries must take account of the different conditions reigning in each area. Where labour is expensive, relative to machinery, mechanisation is stimulated, but where labour is cheaper, it will be used more freely.

While there are economic limits to the expansion of labour productivity, improvements can often be sought in various ways, such as incentive schemes, further mechanisation, better arrangement of fields and buildings and work simplification. Attention should be paid to mechanisation of critical jobs at seasons of the year when the demand for labour is the highest.

But one of the most fruitful ways of increasing labour productivity is to concentrate on expanding production while keeping the labour force relatively static, rather than attempting to reduce labour and keeping production constant. One way to do this is to increase yields through better cultivations, seeds and fertiliser practice, or through better livestock. Also, adjustments in the type of enterprises on a farm may improve the seasonal distribution of work, or a reduction in the number of enterprises, coupled with an increase in the size of each, may result in increased production per worker and a reduction in the problems of management.

1129* WALLACE, D. B.

Effect of Income Tax on Farms and Farming in the Eastern Counties.
Fm Econ. 1952, **7**, 22–29.

The hypothesis that income tax in recent years has reduced farm output is investigated. The basic assumption is that income tax has a greater marginal effect on the farmers with larger incomes. A constant sample of 61 farms for which Farm Management Survey records were available were selected, and a comparison made of production in 1939 and 1949. While the production of the whole sample had risen slightly in the latter year, no correlation could be established between increase in production and size. Therefore the original hypothesis was not proven. However, other lines of investigation showed that the imposition of income tax has had secondary effects, particularly on capital replacement. In times of sharply rising costs, farmers have found it impossible to finance the higher replacement costs from their income after taxation. Taxation has also had a deterrent effect on the expansion of existing enterprises. The conclusion was that farmers in fact look to prices and costs, and that taxation plays a relatively minor part in their conscious planning.

OTHER PAPERS

1100* CLAYTON, E. S. **Replacements (Pullets) at 16s. Each.** *Fmr & Stk-Breed.* 1952, **66** (3247), 87.
WALLACE, D. B. **Costs Race Profits.** *Fmr & Stk- Breed.* 1952, **66** (3255), 41.

AGRICULTURAL ZOOLOGY (including Entomology)

1096* JONES, F. G. W.

Further Observations on the Distribution of the Beet Eelworm.
J. Helminth. 1951, **25**, 223–30.

An account is given of further observations on the distribution of the beet eelworm (*Heterodera schachtii* Schm.) in the period 1944–1950. Scattered infections occur in eastern England from South Yorkshire to the Thames and outlying infections suggest that the eelworm may be more generally dispersed. As yet, there are no records of beet eelworm occurring in Scotland. The limitations of the method of field survey are briefly discussed.

AGRICULTURE

1128* BROOKES, A. J.

The Tethering System for Breeding Pigs.
Essex Pig Soc. Rev. 1952, **2** (2), 32–8.

Reference is made to the advantages of rearing young pigs out of doors. The system of tethering sows is described, and the advantages and disadvantages of this method of management of suckling sows and their litters are discussed.

ENGLEDOW, F. L.

Agriculture in Southern Rhodesia.
Emp. Cott. Gr. Rev. 1952, **29,** 1–11.

A brief, non-technical review of the agricultural resources and development of Southern Rhodesia and of its major agricultural problems.

LYON, A. G. & HOWARD, H. W.

Science and Watercress Growing.
Agriculture : J. Minist. Agric. 1952, **59,** 123–8.

Some of the results of a three-year investigation of the physical and chemical conditions in watercress beds are summarised. An account is given of the main regions of watercress cultivation, and special attention is paid to a survey of the waters used for irrigating the beds. Most of the waters come from the Chalk and are very similar in character. Waters from the Greensand and Lincolnshire Limestone differ somewhat from the Chalk waters. All waters have a temperature of 50°F. at their source and they are usually of pH about 7. They contain adequate supplies of nitrate, potassium, calcium, magnesium and sulphate. but are low in phosphate and iron. Exceptional waters from the Lincolnshire limestone may contain little or no nitrate, and Greensand waters may have adequate phosphate concentrations. The actual concentrations of nutrients are very low, but very large amounts of water (300,000 to 500,000 gallons per acre per day) are used by growers. The only fertiliser used, and suggestions are made for its more efficient use, is superphosphate. The " soil " on the bed bottom appears to be the source of iron for the plant. Changes occur in the characters of the water as it passes down beds, the most important of which for the growth of the crop probably being temperature. Mention is made of a serious disease of watercress known as " Crook Root ".

OTHER PAPERS

MANSFIELD, W. S. **Aftermath of the Combine Harvester.** " *Times* " *Survey of British Agriculture,* March, 1952, p. 7.
WILSON, F. **African Peasant Farming.** *Col. Rev.* 1951, **1** (8), 11–13 ; (9), 14–17.
1106* WILSON, F. **Mechanisation in Colonial Agriculture.** *Corona.* 1952, **4,** 138–43.

ANIMAL BEHAVIOUR

WALTON, A.

The Development of Sexual Behaviour.
Biol. & Human Affairs. 1951, **17,** 67–72.

ANIMAL BREEDING AND GENETICS

1108* BHATTACHARYA, P. & HAMMOND, J.

The Lamb's Tail in Relation to Wool Type in British Breeds and Crosses of Sheep.
J. Agric. Sci. 1952, **42,** 180–83.

Lambs' tails at about a month old have been collected from two or three flocks of several different British breeds and crosses of sheep, and have been classified into ten grades according to the relative amounts of wool or hair extending from base to tip of the tail.

In general the relative amounts of wool and hair found on the tail of the lamb in the different breeds correspond with the quality of the wool of the adult fleeces of the breeds.

Considerable variability in tail grade was found between different individuals in the same flock, so that there is scope for selection in this respect to improve the quality of the wool especially on the britch.

It is suggested that as differences are more obvious on the tail at birth than in the adult fleece, selection for uniformity of fleece might be made at this time.

1084* HAFEZ, E. S. E.

The Influence of Environment and Heredity on the Breeding Season of the Ewe.
Experientia. 1951, **7,** 353.

Pure Dorset Horn, pure Welsh Mountain, and Dorset Horn × Welsh Mountain, first cross ewes were available. They were running continuously with vasectomized rams on pasture for three successive years. The rams were ochred daily and the colour of the ochre was changed fortnightly. Daily observation of oestrus was carried out. In the Dorset Horn, the onset of the breeding season was in late July, the average length of the breeding season was 32 weeks and the number of oestruses per ewe per season was 12. The Welsh Mountain came in season in late October, had a breeding season of 19 weeks and experienced 7 oestruses per season. The Dorset Horn × Welsh Mountain Dorset Horn which came in season in early October, experienced a breeding season of some 26 weeks and manifested 10 oestruses per ewe per season.

1090* Hafez, E. S. E.

Sexual Season in Ewe Lambs.

Nature, Lond. 1951, **168**, 1046.

The sexual season of ewe lambs lasts only a quarter to a third as long as that of adults. The proportion of ewe lambs which did not show any oestrus during the first autumn was 11 per cent. and 20 per cent. in early- and late-born lambs respectively. Silent heat occurred frequently in the late-born animals, and the number of silent heats expressed to the possible total of heats was 7 per cent. and 14 per cent. in early- and late-ewe lambs respectively.

The live weight at the onset of the sexual season (first heat) ranged from 66 to 121 lb. with no significant difference between the two groups.

It is concluded that oestrous performance in ewe lambs is controlled by the daylight environment and the growth-rate.

1135* Hafez, E. S. E.

Studies on the Breeding Season and Reproduction of the Ewe. Parts I-III.

J. Agric. Sci. 1952, **42**, 189–265.

During the course of three breeding seasons, daily observations of oestrus were undertaken on the following groups of ewes, all of which were running with ochred rams. One-hundred and twenty ewes (pure bred and first-cross) of different breeds and ages, running with vasectomized rams under natural conditions. Twenty-eight grade Suffolk ewes fed on a submaintenance diet. Eighteen grade Suffolk ewes running with a fertile. ram. Twenty ewes of several breeds exposed to artificial light.

The effects of heredity (breed and individual), environment (season, year and nutrition), age and artificial light on the breeding season and related phenomena have been investigated. The results and conclusions were as follows :

1. (*a*) There are breed differences in the extent of the breeding season, cycle length, incidence of silent heat and duration of heat. The duration of the breeding season varies in different breeds (weeks : Blackface Mountain 20 ; Border Leicester 19 ; Dorset Horn 32 ; Romney Marsh 24 ; Suffolk 27 ; Welsh Mountain 19 ; Welsh Mountain × Dorset Horn 26). (*b*) The duration of the breeding season is related to the geographical origin (latitude and altitude) of the breed . (*c*) The duration of the breeding season of the first-cross is intermediate between that of the two parents. (*d*) Individual differences in the number of oestrus cycles per ewe per season were more marked in the mountain breeds.

2. (*a*) Of the ewe lambs, 79% exhibited oestrus during the shortest days only of the first breeding season. Their breeding season is not spread evenly about the shortest day as it is with adults. (*b*) The occurrence and length of the breeding season in ewe lambs is associated with early birth dates or with higher growth rates.

3. (*a*) Significant differences exist between breeds in the age at first oestrus. (*b*) Ewe lambs born early in the season showed their first oestrus at later age and heavier weight than those born late.

4. Annual differences in the duration of the breeding season, cycle length, incidence of silent heat and occurrence of first oestrus were negligible.

5. (*a*) Submaintenance diet had no effect on the onset of the breeding season, but it converted oestrus into silent heat. Conception occurred less frequently after periods of underfeeding. (*b*) At high latitudes nutrition has only a minor effect on the breeding season of the ewe.

6. (*a*) A constant high ratio of artificial darkness (8 hr. light : 16 hr. darkness) hastened the onset of the breeding season some 57 and 27 days in the two experimental groups. (*b*) A constant high ratio of artificial light (16 hr. light : 8 hr. darkness) hastened the end of the breeding season some 104 days on an average (in one experimental group). (*c*) There were breed differences in the latency of initiation and of cessation of the induced breeding season. (*d*) In the induced breeding season cycles of ovulation preceded the first oestrus. (*e*) Two thresholds of pituitary activity are suggested, one for the onset of ovulation, and the other for the manifestation of oestrus.

7. (*a*) A high frequency of cycles outside the normal range (14–19 days) was observed in the mountain breeds and in ewe lambs. (*b*) The shortest average cycle length coincided with the shortest days of the year.

8. A high frequency of silent heats (during the breeding season) was observed in the mountain breeds, in ewe lambs and during the second half of the breeding season.

9. Oestrus was of longer duration in adults and yearlings than in ewe lambs.

10. (*a*) Post-partum heat occurred in 56% of Suffolk ewes with an average lactation anoestrus of 35 days. (*b*) There is a relationship between the early onset of the breeding season and the incidence of post-partum heat. (*c*) Conception post-partum is partly inhibited by lactation.

11. Mating behaviour was observed in animals of several breeds and ages (three patterns were recorded for ewes and eight patterns for rams).

12. Irregular columnar cells in the vaginal smear of the ewe characterised late pregnancy.

In addition, the breeding season of wild and domestic sheep was reviewed in relation to the environment with special reference to the length of daylight.

Hammond, J.

Farm Animals : their Breeding, Growth and Inheritance. 2nd. ed.

Pp. viii+266. Arnold, 1952. Price 18*s*.

1112* POMEROY, R. W.

Prenatal Mortality in an In-Bred Strain of Large White Pigs.

2nd Int. Congr. Physiol. Path. Anim. Reprod., Copenhagen, 1952, 5–11.

In 5 generations of inbreeding the average litter size in a herd of Large White pigs fell from 9·9 in the foundation sow to 6·7.

45 sows were killed at various intervals after service ; of these 16 were definitely pregnant, and of the remaining 29, 19 had abnormalities of the genital tract.

Examination of the pregnant uteri indicated that the reduction in litter size was not primarily due to a reduction in the ovulation rate, but rather to either failure of all the ova shed to be fertilized or, more probably, death and resorption of embryos during the early stages of pregnancy.

Inbreeding in this herd has not reduced the ovulation rate but the increase in ovulation rate with litter order characteristic of outbred sows, does not occur.

Outcrossing with inbred boars on unrelated sows suggests that the high proportion of missing ova is not due simply to failure of fertilisation as a result of defective production of spermatozoa by the boars.

Outcrossing with outbred boars on the inbred sows suggests that the heavy prenatal mortality is characteristic of the inbred sows and not of the inbred embryos.

OTHER PAPERS

HAMMOND, J. **Improvement of Dairy Cattle.** *Brit. Cattle Breed. Cl.* 1950, **6a,** 173–224.
HAMMOND, J. **Radical Changes Forecast in Breeding Methods.** *"Times" Agric. Rev.* Summer, 1952, p. 5.
PEASE, M. S. **Starting from the White Leghorn.** *Autosexing Annu.* 1951, 22–5.
PEASE, M. S. & COCK, A. **Retarded Pigmentation. A New Gene Affecting Down Colour and Pattern.** *Autosexing Annu.* 1952, 9–12
POMEROY, R. W. **Our Sheep Population : Importance of Breeding.** *Brit. Fmr.* 1951 (42), 9.

ANIMAL NUTRITION

1114* PÁLSSON, H. & VERGÉS, J. B.

Effects of the Plane of Nutrition on Growth and Development of Carcass Quality in Lambs. Part I.

J. Agric. Sci. 1952, **42,** 1–92.

Two series of half-brother-sister lambs of balanced sexes have been reared on widely different (High and Low) planes of nutrition from the end of the third month of foetal life to 41 weeks of age. The effect of this on the growth in live weight and relative development of the body proportions has been studied.

The study of the age changes in the High-Plane lambs further proved the theory put forward by Hammond (1932) that in the sheep in post-natal life the different anatomical regions and tissues of the body grow differentially and in a definite order of development. The dressed carcass is later maturing than the organs and offal parts as a whole.

The marked heterogonic growth of the organs appears to be related to their function. Those organs of most vital function to the life of the animal like the brain, eyes, lungs, kidneys, heart, oesophagus, abomasum and small intestines, are relatively well developed at birth, and consequently grow proportionately less in post-natal life than organs like the rumen and reticulum, which have an unimportant function until after the lamb begins to consume fibrous foods, or those whose function is largely that of storage of nutrients, which develop mainly in the later stages of growth.

The development of the different joints or body regions exhibits a marked gradient of increasing growth rate from the head and feet to the loin region, the feet and head growing least and the loin most in post-natal life, while the legs, neck, and shoulders are in an intermediate position, the legs being earlier maturing than the shoulders.

The major tissues of the body exhibit marked differential growth rates in post-natal life. The order of increasing growth rate with age follows an outward trend from the central nervous system to bone, tendon, muscle, intermuscular fat and subcutaneous fat. Consequently, the early maturing nervous tissue and the skeleton make a greater proportion of their growth earlier in life than does muscle and fat ; the latter, particularly subcutaneous fat, does not develop to any great extent until late in the growing period.

Within any of the major tissues, bone, muscle and fat, well-defined growth gradients are observed.

Marked differences between the sexes are apparent. The High-Plane males were on the average 15% heavier at birth than the females, which was found to be significant at the 5% level. At 41 weeks the wethers weighed 215·5 lb. and the ewes only 144·75 lb. This great difference appears to be principally caused by a longer span of growth in the wethers and by their higher rate of growth during the latter part of the growing period, rather than being due to their higher birth weight, for the females grow at a faster rate immediately after birth, and at 2 weeks of age have reached a greater average live weight than the males.

At 9 weeks of age the ewes were in a more advanced stage of development in respect of all characteristics than the wethers. The latter were proportionally less developed in all the late maturing characters such as dressed carcass percentage, had less fat and more bone, and each tissue was proportionately less developed in the late maturing joints in the wethers than in the ewes.

At 41 weeks the picture was completely reversed in every respect. The wethers at that age had not only reached 50% greater weight than the ewes but all their tissues and body proportions were in a more advanced stage of development, i.e. the later maturing tissues and anatomical regions were proportionately better developed in the wethers than in the ewes. At both ages these differences were reflected in photographs of the carcasses and the limb bones as well as in the carcass measurements.

The vastly different quantitative planes of nutrition of the High- and the Low-Plane lambs did not affect all the parts and tissues of the body equally, so that the Low-Plane lambs were not miniature images of the High-Plane lambs at the same age. On the contrary, the restricted nutrition of the Low-Plane lambs affected the different anatomical regions, organs and tissues of the body differentially and in an orderly manner.

The dressed carcass is more affected by the restricted nutrition in post-natal life than the organs and offal parts with the exception of the abdominal fats.

Of all the organs, the earliest developing brain and eyes are least affected in the Low-Plane lambs. At 41 weeks the brain is only 5% heavier in the High- than the Low-Plane lambs, which is statistically insignificant for the available degrees of freedom ; as the difference was proportionately greater at birth, poor nutrition in post-natal life appears to have no effect on the brain weight, while it may do so to some extent in foetal life. The ewes have a significantly lighter brain than the wethers (corresponding to their smaller live weight at birth). The eyes, though but slightly affected compared with other organs and body parts, are significantly lighter in the Low-Plane series at 41 weeks.

An organ of great growth intensity at any particular age interval is much more affected by the restricted nutrition during that interval than at other ages, i.e. the abomasum before birth, the rumen and the thymus glands from birth to 9 weeks, and the caul and kidney fats from 9 to 41 weeks old.

At birth the major tissues of the carcass are differentially affected by the restricted nutrition, the brain being least affected followed by the skeleton, muscle, tendon and fat. In post-natal life these tissues are affected in the order of increasing growth intensity, with age ; the brain is least affected, followed by the skeleton, muscle, intermuscular fat, kidney fat and subcutaneous fat.

Not only does the plane of nutrition affect the weight of the individual skeletal units differentially, but it also affects the form of the bones in a comparable way. The late developing growth in thickness is retarded by poor nutrition to a much greater extent than the earlier developing length growth in post-natal life, while in foetal life the length growth of the early maturing cannon is more affected than its late maturing growth in thickness, the latter having very low growth intensity in foetal life as compared with the length growth. The differential effect on the form of the metacarpals over the whole experimental period is so great that those of the Low-Plane lambs at 41 weeks resemble bones of semi-wild or unimproved late maturing breeds, being very thin and round, while the cannon bones of the High-Plane lambs at 9 weeks and much more so at 41 weeks, have the thick flattened shaft characteristic of early maturing improved breeds.

The effect of the Low Plane of nutrition on the development of muscle, intermuscular fat and subcutaneous fat, as in the skeleton, exhibits a gradient from the early to the late maturing regions of the body in each case, i.e. the latest maturing parts are most and the earliest developing least affected.

The wethers appear to be more sensitive to restricted nutrition than the ewes and more so in the late maturing tissues and anatomical regions of the body. The proportionately more advanced development of the High-Plane wethers at 41 weeks as compared with the ewes is more than completely suppressed by the restricted nutrition of the Low-Plane wethers, the latter being in a less advanced stage of development than the ewes of the same treatment group at the same age.

Though an animal which has been retarded in its development by restricted nutrition retains more of the juvenile form than another of the same age which has been growing it its full inherent capacity, it is, however, not merely anatomically younger, corresponding to the weight difference, because of the differential effects of the restricted nutrition on the different organs, parts and tissues of the body. That even within a tissue some parts are penalized proportionately more than others by restricted nutrition during a period of active growth, has been tested statistically in the skeleton and found to be true.

Practical applications of some of the results are discussed.

1115* Pálsson, H. & Vergés, J. B.

Effects of the Plane of Nutrition on Growth and Development of Carcass Quality in Lambs. Part II.

J. Agric. Sci. 1952, **42**, 93–149.

Four groups of half-brother-sister lambs of eight individuals, each of balanced sexes, have been reared on quantitatively different planes of nutrition so as to grow along predetermined growth curves until they reached 30 lb. dressed carcass weight when killed. Treatment differences started at the end of the third month of foetal life. One group was reared on a High Plane of nutrition throughout (High-High), another on a High Plane up to 6 weeks of post-natal life followed by a Low Plane (High-Low), the third on a Low Plane up to 6 weeks after birth, followed by a High Plane (Low-High), and the fourth on a Low Plane throughout (Low-Low). The High-High lambs were killed at 9 weeks old, the High-Low and Low-High at 15 weeks and the Low-Low at 41 weeks old. This allowed for comparison of animals of the same carcass weight but different age and of animals of the same age and carcass weight, but having differently shaped growth curves. The relative effects of the treatments on the development of the body proportions and carcass quality have been studied.

The weight of the head is more affected by the age of the animal than by the plane of nutrition or the carcass weight, it being of the same weight in the Low-High and High-Low lambs, but significantly lighter in the

High-High and significantly heavier in the Low-Low groups. The skin, with wool, was much heavier in the Low-Low than in the other groups, while the weight of the blood was directly affected by the plane of nutrition prior to slaughter, it being significantly heavier in the High-High and Low-High groups than in the High-Low and Low-Low ones.

The development of the brain and the eyes was found to be primarily a function of age, these organs being lightest in the High-High and heaviest in the Low-Low group. The brain (as in Part I) appeared to be earlier maturing than the eyes, the differences between the age groups all being significant in the case of the latter, but only the High-High lambs had significantly lighter brain than the other groups.

The development of organs like the oesophagus, the rumen, the reticulum, the omasum and the genital organs, appears to be more influenced by age than the plane of nutrition, while that of the abomasum, the caecum, the large intestines, the rectum and the pancreas, is influenced by the plane of nutrition as well as age.

In general, the organs appear to have priority claim for the available nutrients in the blood stream to allow them to develop to such an extent, which enables them to cope with their function at any age. When the nutritive supply is low, organs, whose function is directly associated with growth, suffer proportionately more than those which are of primary importance for life, like the brain, the eyes and the heart.

The four treatments produced two distinct types of carcasses. The High-High and the Low-High carcasses were of very similar conformation, short in the leg, blocky and well covered with subcutaneous fat, with the late maturing trunk joints proportionately better developed compared with the High-Low and Low-Low carcasses, which in conformation resembled each other, and were leggy, lank and badly covered with subcutaneous fat. In the latter two groups the early developing legs and neck were proportionately better developed than the later maturing trunk joints.

Marked differential effects were produced on the carcass composition. Bone in the dressed carcass was significantly lighter in the Low-Low than in the other groups, due to the inhibiting effects of continuous undernutrition on growth in thickness of bone. The difference in bone weight between the other groups was insignificant, though the High-Low had the heaviest bone in the carcass. Muscle was better developed in the High-Low and the Low-Low groups than in the Low-High and High-High groups, while fat, especially the subcutaneous fat, was better developed in the two latter groups.

A High Plane of nutrition prior to slaughter appears to be essential for good development of the latest maturing tissue, the subcutaneous fat. Under limited food supply the earlier maturing tissues, muscle and bone, especially for growth in length, have priority claim for the available nutrients.

The ewes had significantly lighter bone, slightly lighter muscle, though insignificantly so, and significantly heavier fat than the wethers.

All tissues show great recuperative capacity if provided with adequate food supply after restricted nutrition, unless at that time they have passed their age of high growth intensity.

Comparison of the development of the different anatomical units of the major tissues in the High-High and Low-Low carcasses showed that within each tissue the latest maturing parts suffered proportionately more from the continuous undernutrition, with the exception of the ribs, which, though the latest maturing part of the skeleton, were of the same weight in the Low-Low as the High-High, though total bone in the carcass was heavier in the latter. This is accounted for by the so late onset of high growth intensity in the ribs that the High-High lambs were killed before the ribs could benefit from the good nutrition as much as earlier maturing parts of the skeleton, while in the Low-Low, the ribs, having high growth intensity for a long time after the growth rate of earlier developing parts of the skeleton had declined, could compete for nutrients with considerable success with still later maturing tissues, muscle and fat.

In the skeleton the shape of individual bones was much more affected by the different treatments than their weight. This accounted for the great treatment differences in carcass conformation. The earlier maturing growth in length is much less affected than the later maturing growth in thickness, and the earlier maturing bones like the cannons are less affected than the later maturing femur or the pelvis.

The four treatments caused great and highly significant differential effects on the various carcass measurements. As some of these measurements have been found by previous workers to be even more important indices of meat quality than is the actual composition of the carcass, it may be claimed that the different treatments have affected carcass quality even more than carcass composition.

The females had significantly better developed fat measurements than the wethers, while no significant sex differences were observed in the other measurements.

Considering the several factors studied which affect carcass quality, the High-High lambs yielded carcasses of the best quality, especially the females, closely followed by the Low-High ones, while the Low-Low carcasses were of much inferior quality and the High-Low still poorer. Those of the latter two groups were more typical of an unimproved late maturing breed than being of the same breed as the High-High and Low-High carcasses.

WOODMAN, H. E.

Rations for Livestock. 12th ed. Pp. iv+144.
H.M.S.O., 1952. Price 4*s*.

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HALNAN, E. T. **This Protein Business.** *Poult. Assoc. G.B. Yearb.*, 1952, 82–5.
HALNAN, E. T. **Effect of Nutrition on the Efficiency of the Breeding Hen.** *Spillers Livestock Mag.* 1952 (54), 4–7.
1082* BROOKES, A. J. **Rearing Dairy-bred Calves for Beef.** *Agriculture : J. Minist. Agric.* 1951, **58,** 365–70.
1105* BROOKES, A. J. **Levels of Rearing in Beef Production.** *Hereford Agric. J.* 1952, **12** 239–51.
BROOKES, A. J. **Rearing Cattle for Beef.** *J. Yorks Agric. Soc.* 1952, **103,** 32–41.

1119* Edgar, D. G.

Progesterone in Body Fluids and Tissues.

2nd Int. Congr. Physiol. Path. Anim. Reprod., Copenhagen, 1952, 168–72.

Using a physico-chemical method which has been developed for the determination of progesterone, this hormone was found in blood from the ovarian vein draining an active ovary in the pregnant and non-pregnant ewe and in the non-pregnant sow. It was not found in blood from the ovarian vein of one ewe with inactive ovaries, nor in the peripheral blood of the pregnant and non-pregnant ewe, mare, cow and sow.

It was present in fluid from the nature Graafian follicle of the cow and sow, and in fluid from ovarian cysts in the sow.

The progesterone content of corpora lutea from three species was also determined.

These findings are discussed, and other possible uses of the technique are suggested.

Hafez, E. S. E.

Fertility and Nutrition in the Ewe.

Proc. 6th Int. Congr. Anim. Husb., Copenhagen, 1952. Sect. III, 35–7.

Submaintenance feeding when started before the onset did not delay the breeding season. Silent heats, however, were more frequent in underfed yearlings than underfed adults. Failure to conceive was associated with the degree of submaintenance and more services were required per conception even at the peak of oestrous activity.

1095* Hafez, E. S. E.

Reproduction in Sheep, and the Response to Artificial Light.

Experientia. 1951, **7,** 423.

Adult ewes of six pure British breeds (namely Dorset Horn, Border Leicester, Romney Marsh, Suffolk, Blackface Mountain and Welsh Mountain) were subjected to artificial darkness at the end of the sexual season (April 15, 1950). Control groups of the six breeds were kept on pasture under natural conditions of daylight. Ochred vasectomized rams were running continuously with both experimental and control groups, and oestrus was recorded every morning. The onset of the sexual season was hastened in the experiment breed groups by 44 to 70 days with an average of 57 days ; the different breeds started to come in oestrus in the same order as they did in the controls. The latency of initiation (time lag from the start of light treatment to the response, first oestrus) was 10 weeks in the Dorset Horn, 16 weeks in the Border Leicester, 17 weeks in the Romney Marsh, 18 weeks in the Suffolk and Blackface Mountain, and 19 weeks in the Welsh Mountain.

1131* Hammond, J.

Induction of Milk Secretion.

Colloque Intern. CNRS. Strasbourg, 1950. Pp. 9–14.

This paper describes the various stages through which the mammary glands develop in the process of the initiation of lactation, together with the causes for them so far as they are known. These are considered in their quantitative as well as in their qualitative aspects. Attention is also drawn to problems which have yet to be solved if complete quantitative control over the initiation of lactation is to be obtained.

The early foetal stages of development are produced by gene controlled organizer substances rather than by sex hormones. Towards the end of foetal life in cattle, however, sex differences in development of the mammary gland begin to be shown and reasons are given for supposing that these are due to stimulus by female sex hormones rather than to inhibition by male sex hormones. Development of the duct and alveolar system at this stage, which in the cow continues up to the 20th week of the first pregnancy, imposes a quantitative limit to the amount of milk that can be produced at the subsequent phase of development.

The next well marked stage in the initiation of lactation in the cow occurs slightly after the middle of the first pregnancy when the metabolism of the alveolar cells changes over from that of an epithelial skin cell to that of a glandular mammary cell. A comparison of these changes in different species, and the experimental results obtained by implantation of the synthetic oestrogen stilboestrol in different species, suggests that differences in the results obtained on implantation depend on the different hormone balances normally existing in the various species.

It is suggested that the initiation of alveolar cell development depends on high levels of both oestrogens and progesterone in the blood, independently of whether or not these substances act through the medium of the lactogenic hormone of the anterior pituitary. There are indications that a high ratio of progesterone to oestrogen increases the volume of alveolar cell growth, whereas a high ratio of oestrogens to progesterone encourages the rapid development of milk secretion by the alveolar cells. A change in this ratio occurs during the normal course of pregnancy in the cow and during pseudo-pregnancy in the rabbit, the quantity of milk produced being dependent on the duration and intensity of the high ratio of progesterone to oestrogen phase.

Another quantitative aspect of the initiation of lactation is the effect of the plane of nutrition of the animal during the time when the hormone stimulus to development of the alveolar cells occurs. It would appear that alveolar tissue can be built up from incoming nutrients only and not by withdrawals from other body tissues.

1134* Hammond, J.

Nutrition and Fertility.
Proc. 6th Int. Congr. Anim. Husb., Copenhagen, 1952. Sect. III, 38–45.

The modes of action of the various factors in nutrition are discussed as to whether they act on the anterior pituitary, gonads, or accessory organs.

The number of eggs which ripen in the ovaries depends on the plane of nutrition, a given quantity of F.S.H. stimulating more follicles if the plane of nutrition is high, for in this case there are more follicles with an antrum. Failure to ripen follicles occurs under conditions of phosphate deficiency or in certain species during lactation. This may be due to an inhibition of anterior pituitary secretions.

The number of eggs shed which get fertilized is affected by the occurrence of " still heats " which result from low plane nutrition. Lack of energy nutrition decreases the output of testosterone and so sexual desire ; this also occurs in fat animals, probably because of the solubility of testosterone in fat. Sterility in males may be associated with liver lesions which can be caused by diets deficient in animal proteins.

The number of eggs fertilized which develop properly to produce viable young is reduced in poultry by lack of A.P.F. in the ration. In mammals it is possible that it may be caused by lack of phosphates, or Vitamin A, or the presence of oestrogens in the feed. The plane of nutrition during late pregnancy affects the size and viability of the young at birth.

Hancock, J. L.

The Morphology of Bull Spermatozoa.
J. Exp. Biol. 1952, **29,** 445–53.

This paper describes the results of experimental investigations which show that the morphological features of bull spermatozoa are altered after death. The results are discussed with reference to previous work on the morphology of bull spermatozoa. It is pointed out that previous workers have described two cap-like structures investing the head of the bull spermatozoon ; it is concluded that these two structures, the acrosome and the *galea capitis*, are identical. It is suggested that the cap of the bull spermatozoon should be referred to as the acrosome.

1087* Hancock, J. L.

Physiological Aspects of Fertility in Cattle.
J. Endocrinol. (Proc.). 1951, **7,** 42–7.

In this paper an attempt was made to classify the patterns of sexual activity in cattle and to define the hormonal mechanisms which govern these patterns. Attention was drawn to the variations in sexual behaviour which occur in cattle, and to the associated variations in ovarian activity which are recognizable by clinical examination. The part played by the oestrogenic hormones and progesterone in the regulation of oestrous behaviour in the normal animal was discussed. The endocrinological significance of certain forms of functional infertility was examined with reference to the results of experimental and clinical observation.

1109* Hancock, J. L.

The Spermatozoa of Sterile Bulls.
2nd Int. Congr. Physiol. Path. Anim. Reprod., Copenhagen, 1952, 35–40.

Sterility in certain Friesian bulls is associated with a specific morphological abnormality affecting the acrosomes of their spermatozoa.

This abnormality is visible in living spermatozoa and when precautions are taken during fixation to. preserve the morphology of the living cell it is also visible in killed and stained spermatozoa.

If such precautions are not taken, and the spermatozoa are subsequently stained with nigrosin-eosin, or with Heidenhain's iron haematoxylin, or when such spermatozoa are examined with the phase-contrast microscope, the abnormality is inconspicuous.

These difficulties do not arise when Giemsa stain or Indian ink is used.

1132* Maqsood, M.

Influence of Thyroid Status on Spermatogenesis.
Science. 1951, **114,** 2974.

Administration of thyroxine in optimal physiological doses to 4-week-old male rabbits for a period of about 16 weeks resulted in precocious sexual development as judged by the onset of libido, semen qualities, and testis histology. On the other hand, thiouracil treatment arrested the onset of sexual maturity. The seminiferous tubules showed degenerative changes,

Administration of thyroxine and thiouracil to young rams for a period of one year produced practically the same effects on the process of spermatogenesis and the development of the interstitial cells of the testes as those described above for the thyroxine- and thiouracil-treated rabbits, respectively.

MAQSOOD, M.

Rôle of Thyroid on Male Reproductive Processes.
Proc. 2nd Int. Vet. Zootech. Conf. Madrid, 1951, 30.

The administration of thyroxine within the optimal physiological doses resulted in precocious sexual development and stimulated the male reproductive processes in some species of animals. Thyroxine when administered in amounts below or about equal to the estimated thyroxine secretion rate in the young male rabbit had no effect on the development and functions of the male sex organs. The continuous administration of thyroidal materials in moderate doses to the young Suffolk ram during the non-breeding season practically maintained the male reproductive processes to those levels observed during the breeding season. Prolonged thiouracil treatment arrested the onset of sexual maturity in the young male rabbit and the ram. The present studies suggest some interesting possibilities for thyroid hormone therapy in the field of Animal Husbandry particularly under conditions where the thyroid hormone secretion rate may be subnormal.

1133* MAQSOOD, M.

Seasonal Variations in the Testis Histology of the Ram.
Vet. Rec. 1951, **63**, 597.

Histological examination of the testis sections of the young Suffolk rams during the non-breeding season showed arrested spermatogenesis and an increase in size and number of protoplasmic droplets in majority of the seminiferous tubules when compared with those observed during the breeding season. A comparative decrease in the number of the interstitial cells was also observed in the testis during the non-breeding season.

MAQSOOD, M.

Thyroid Functions in Relation to Maturity and Fertility in the Male.
Proc. Soc. Study Fertility. 1951, **3**, 33–9.

The effects of administration of thyroxine and thiouracil upon the age of maturity, libido, semen qualities and testes histology were carried out on young Suffolk rams and male rabbits. From the results obtained it seems quite clear that the mild degree of hyperthyroidism is conducive to optimal sexual development and reproductive performance. Prolonging thiouracil treatment or thyroidectomy in the young animal arrests the onset of sexual maturity. During the period of sexual decline in male fertility in the sheep there occurs a decrease in the thyroxine secretion rate and administration of thyroxine practically maintains the male reproductive processes to those levels observed in the breeding season.

1130* MAQSOOD, M.

Thyroid Functions in Relation to Reproduction of Mammals and Birds.
Biol. Rev. 1952, **27**, 281–319.

The contradictory results obtained by a number of investigators on the effects of the thyroid status on various reproductive processes in certain species of animals appear to be due to lack of appreciation of the normal thyroxine secretion rate of the animal during the administration of thyroidal materials.

The discovery of various goitrogens, i.e. many derivatives of aniline and thiourea, and the manufacture of these compounds and of thyroxine synthetically, has provided a new approach to the study of thyroid physiology.

Broadly speaking, the beneficial effects of thyroid therapy within physiological limits on the various reproductive processes can be summed up as follows :

(1) Mild hyperthyroidism stimulates sexual development, while hypothyroidism interferes with the normal development of sex organs, in the young mouse.

(2) Continuous administration of thyroxine within the optimal physiological doses results in precocious sexual development in the young male rabbit, and improves the sexual desire and semen qualities of the treated animals. Thyroxine therapy greatly improves the libido and semen quality and stimulates spermatogenesis in subfertile rabbits which before the treatment showed very poor libido, deterioration in semen quality and arrested spermatogenesis. The decrease in the thyroxine secretion rate which occurs with advancing age is linked up with poor fertility in older rabbits.

(3) Feeding of thyroidal materials results in an increase in egg production, especially in pullets, and considerably prevents the seasonal and yearly decline in egg production in some breeds of poultry. The administration of thyroxine stimulates feather growth and hastens moulting in poultry. The quality of semen collected from thyroxine-treated young cockerels of some breeds shows some improvement compared with that of controls.

(4) The administration of thyroxine in physiological doses results in precocious sexual development in the young Suffolk ram lamb, and there was considerable improvement in libido and semen quality when compared with that of the control group. The testes of the treated animals shows active spermatogenesis and the interstitial cells appear well developed and more numerous. Continuous feeding of thyroxine during the early spring and summer months prevents the seasonal decline in fertility in young rams. There are indications

that the decrease in thyroxine secretion rate which occurs during the summer season is responsible for the seasonal decline in male fertility in sheep.

(5) Thyroxine therapy, by stimulating the process of spermatogenesis in the testes of some species of animals, checks those types of sperm abnormalities which appear to be associated with defective spermatogenesis.

(6) Thyroid therapy improves the sexual desire and sex drive in the bulls and boars which before the treatment showed very poor sexual desire.

(7) The addition of thyroxine in critical concentrations to bull-semen samples of average sperm density results in a significant increase in the oxygen uptake of the spermatozoa after 24–46 hr. storage at +5°C. The addition of thyroxine to bull semen appears to have some practical application in the field of artificial insemination.

The administration of large doses of thyroidal materials beyond the physiological limits adversely affected the normal development and functions of the sex organs. The severity of the effects varied with the dose and duration of the hormone administered, species and age of the animal and the environmental conditions.

Thyroidectomy or prolonged thiouracil treatment arrests the onset of sexual maturity in some species of growing animals. The administration of thiouracil adversely affects the various reproductive processes in the rabbit and ram. In poultry, thyroidectomy or thiouracil treatment results in a marked decline in egg production and egg weight, and interferes with the growth of feathers.

The mechanism whereby the thyroid gland influences various gonadal functions probably involves a complex series of interactions. The mechanism of action of the thyroid hormone on the development of sex organs, the relation between thyroid functions and seasonal decline in male fertility, thyroid gland and subfertility, and the role of thyroid status on egg production in poultry, are discussed in the light of previous work.

1110* Marden, W. G. R.

The Hormone Control of Ovulation in the Calf.

2nd Int. Congr. Physiol. Path. Anim. Reprod., Copenhagen, 1952, 154–65.

Unlike most mammals the calf is capable of responding to pituitary injections almost from birth. Age has little effect on the ability of the follicles to develop during a series of F.S.H. injections, the follicular response generally being as good, three weeks after birth as in calves 6—8 months old.

In the calf ovulation can occur spontaneously following F.S.H. treatment before the end of the first month of post natal life. Ova obtained from such ovulations are capable of fertilisation though the percentage becoming fertilised is very low. This is thought to be due to difficulties in insemination rather than to faulty maturation of the ova.

Though many follicles (10—60) can develop during a series of F.S.H. injections, superovulation can not consistently be obtained either by intravenous injections of L.H. or P.U. or a combination of these two.

Superovulation can generally be obtained with the formation of many corpora lutea if F.S.H. treatment is repeated a second time after a period of luteal activity.

The inhibiting effect of a corpus luteum on ovulation in cattle can be overridden in the F.S.H. treated animal if suitable quantities of L.H. or P.U. are intravenously injected when the newly formed follicles are approaching maturity.

Ovulation in the calf at all ages up to 8—9 months of age either in the presence or absence of luteal tissue, is unaccompanied by oestrus.

Marshall's Physiology of Reproduction. Edited by A. S. Parkes. Vol. 2. 3rd ed. Pp. xx+880. Longmans, 1952. Price £7 10*s*.

In this new edition A. St. G. Huggett and J. Hammond contribute the chapter on " Physiology of the Placenta "; F. H. A. Marshall and J. C. Moir " Parturition "; J. Hammond " Fertility "; and J. Hammond and F. H. A. Marshall " The Life-cycle ".

1088* Perry, J. S.

Reproduction of the African Elephant, *Loxodonta africana.*

J. Endocrinol. (Proc.). 1951, **7,** 53–7.

Between December, 1946 and December, 1948 and January to March 1950, 150 elephants made available in the course of control work carried out by the Uganda Game Department, were examined in greater or less detail according to circumstances.

The significant features of the elephant ovary in relation to pregnancy are :

(1) the formation of several small, relatively short-lived corpora lutea, some by ovulation and some not, before conception occurs ;

(2) the formation of a number of ' accessory ' corpora lutea early in pregnancy, some by ovulation and some not ;

(3) the replacement of these by another similar set about half-way through the pregnancy ;

(4) the persistence of these corpora lutea to term, followed by their precipitate decline and a prolonged lactation anoestrus.

1113* Polge, C. & Rowson, L. E. A.

Long-term Storage of Bull Semen Frozen at Very Low Temperatures (—79°C.).
2nd Int. Congr. Physiol. Path, Anim. Reprod., Copenhagen, 1952, 90–98.

A technique is described for the preservation of bull semen frozen in solid carbon dioxide at —79°C. The survival of the spermatozoa under these conditions is dependent upon the use of diluents containing glycerol.

Optimal conditions for freezing are : (i) Dilution of the semen at 5°C. with a citrate buffer containing glycerol to give a concentration of 10% glycerol in the semen. (ii) Equilibration of the semen and diluent for 12 to 20 hours at 5°C before freezing. (iii) Cooling the semen slowly at a rate which should not exceed 2° per minute between 5°C. and —15°C., although below —15°C. the rate may be quicker. Up to 80% of the spermatozoa may resume motility after freezing by this technique and thawing at 40°C.

In 21 cows inseminated with unfrozen semen containing glycerol a pregnancy rate of 76% was obtained.

38 cows inseminated with glycerol-treated semen, which had been frozen at —79°C., gave a pregnancy rate of 79%.

In preliminary experiments on long-term storage, pregnancies have been obtained from semen kept frozen at —79°C. for 20 weeks.

The possibility of very prolonged storage of semen and its application to artificial insemination is discussed.

1118* Walton, A.

The Survival of Spermatozoa *in vitro* and the Measurement of Motility.
2nd Int. Congr. Physiol. Path. Anim. Reprod., Copenhagen, 1952, 204–8.

The author summarizes in brief the main factors influencing the survival of spermatozoa *in vitro*, such as temperature, pH composition of diluents and addition of antibiotics.

The possibility of deep freezing technique superseding other preservation methods in future is mentioned, and the need for a further development of the methods for the investigation of the motility and the metabolic rate of the spermatozoa is emphasized.

OTHER PAPERS

1127* EDGAR, D. G. **Progesterone in Body Fluids.** *Nature, Lond.* 1952, **170,** 543.
POLGE, C. & ROWSON, L. E. A. **Fertilizing Capacity of Bull Spermatozoa after Freezing at —79°C.** *Nature, Lond.* 1952, **169,** 626–7.

ANIMAL PRODUCTION

1121* Hammond, J.

Adaptation of Livestock to New Environments.
Proc. U.N. Sci. Conf. on Conservation, New York, 1949, **6,** 414–21.

The effects of various environmental conditions (such as darkness-daylight hours, air temperatures, sunlight, humidity and poor nutritive conditions) on the animal are described in relation to the main factors affecting the economy of production such as survival rate, fertility, rate of weight gain and milk production.

A knowledge of the optimum time of breeding in relation to the changes in daylight-darkness hours is one of the main factors affecting lambing percentages obtained in sheep.

The chief factor which has prevented the wide utilization of the improved European breeds of animals in tropical areas is that of high air temperatures. One method of overcoming this is by the formation of new breeds combining the heat tolerance of native breeds with the high producing qualities of improved European breeds. This could be speeded up if a large number of breeding centres throughout the tropics would agree to concentrate on the same cross, so that there could be exchange of breeding stock.

In areas of poor nutritive conditions it is impossible to make proper genetic selection for high producing qualities, but the formation of stud farms feeding above the general level in the area and providing males for use within the area, is the best means of effecting improvement until general nutritive conditions are improved. Where large differences in nutritive environment exist it is better to blend the newly introduced improved breed with the native than to try and keep it as a pure breed.

1115* Hammond, J.

Objective Tests for Quality in Meat.
Ann. Nutr. Aliment. 1952, **6,** 119–32.

An account of the various factors which affect quality in meat are described and illustrated under headings of " Weight of Carcass ", " Proportion of Joints ", " Thickness of Muscle and Shortness of Bone ", " The Fat Covering ", " Texture of Meat ", " Colour and Flavour ". Examples of these are taken mainly from mutton and lamb. In addition to these, other qualities of importance for beef, pork, and bacon are discussed.

1097* Hammond, J.

Physiological Limits to Intensive Production in Animals.

Abstracted from the Agricultural Section of the Edinburgh Meeting of the British Association for the Advancement of Science.

Brit. Agric. Bull. 1951, **4,** 222–4.

In physiology the animal adjusts itself to its environmental conditions and those which do not, perish. This adjustment mechanism sets up in the body a series of priorities as regards nutriment and other requirements which render the animal stable in the environmental conditions under which it exists. There exists between the different tissues and parts of the body a graded series of priorities for any nutriments which are available in the blood stream. We can develop intensive production in meat animals, therefore, if we raise the nutrition environment at the same time as selection is being made for a high proportion of the later developing and more valuable parts of the body. The same basic principles apply also to milk production except in that the growth of the mammary gland is superimposed on the growth curve of the animal as a whole, and has several cycles of growth during the life of the animal.

1085* Hammond, J.

The Pig as a Producer of Food. Pp. 132–44.

Contr. to *Four Thousand Million Mouths.* Ed. by F. Le Gros Clark & N. W. Pirie. Oxford Univ. Press, 1951.

A short account of the value of the pig in converting feeding stuffs into human food, and of the various methods by which the efficiency of conversion can be increased viewed from a world food supply angle.

1111* Lamming, G. E. & Rowson, L. E. A.

Superovulation and Ovum Transplantation in Cattle.

2nd Int. Congr. Physiol. Path. Anim. Reprod., Copenhagen, 1952, 144–53.

The paper reviews recent research on superovulation and ovum transplantation in cattle. Experiments have shown that pregnant mares' serum (P.M.S.) may be conveniently used to superovulate cows and conditions affecting the response of cows to P.M.S. are discussed. It has been shown that the presence of a corpus luteum in the ovary, or the injection of progesterone, at the time when P.M.S. is given will result in the production of ova which are not fertilized after artificial insemination. In the presence of a corpus luteum, the ova produced by intravenous injection of luteinizing hormone, travel down the Fallopian tubes at a greatly increased rate.

A review is given of experiments designed to investigate methods of ovum transplantation not involving laparotomy, which could be used in a commercial scheme operated by laymen. It was noticed that the uterus is more susceptible to infection when a corpus luteum is present in the ovary, and this may necessitate aseptic techniques. Methods of transplanting ova aseptically via the cervix have been attempted without success. It is felt that the special methods necessary to maintain complete asepsis may limit the practical application of ovum transplantation in cattle.

1120* Marden, W. G. R. & Chang, M. C.

The Aerial Transport of Mammalian Ova for Transplantation.

Science. 1952, **115,** 705–6.

Fertilized rabbit ova at the 2- and 4-cell stage were washed from the tubes of rabbits at the Worcester Foundation, U.S.A., and shipped by air in a thermos flask at 12°C. to Cambridge, England. They were transplanted into pseudo-pregnant does 26 hours after ovulation, and although the percentage of development was low 2 offspring were produced by one recipient doe.

1125* Marden, W. G. R. & Chang, M. C.

The Aerial Transport of Fertilized Mammalian Ova.

2nd *Int. Congr. Physiol. Path. Anim. Reprod., Copenhagen.* 1952, 140–43.

Fertilized segmenting rabbit ova are capable of surviving aerial transport over long distances. Two different breeds of rabbits have been established from ova fertilized in the United States and flown *in vitro* to the United Kingdom.

The percentage of development was only 10% in the first experiment, where only 2-cell ova were used, and 30% in the second experiment from which all ova developing were transplanted at the 4-cell stage.

The ova were shipped in small phials (1 ml. capacity) containing whole blood serum, to which a drop of penicillin had been added. These were put into a thermos flask containing small ice balloons and shipped by air. The time interval from recovery of the ova to time of transplantation was 27–30 hours.

Robinson, T. J.

Reproduction in the Ewe.

Biol. Rev. 1951, **26,** 121–57.

The relative low prolificacy of the ewe is a factor severely limiting the sheep's ability to compete with other forms of livestock production in intensive agriculture. This article is an attempt to examine critically

all the available information on the reproductive physiology of the ewe, with particular emphasis on the factors controlling the various phenomena and the possibility of increasing prolificacy.

All breeds exhibit, to a greater or less extent, a breeding season which is under light control. Available data on the extent of this season are tabulated.

The ' height ' of the breeding season corresponds roughly to the shortest day of the year, and the ' depth ' of anoestrum to the longest day.

This, and other data suggest a seasonal fluctuation in pituitary gonadotrophic activity controlled by, and roughly inversely related to, the period of daylight relative to dark. It reaches a maximum when the days are shortest and a minimum when they are longest.

The ability of some breeds to come into oestrus and conceive shortly after parturition depends on the breeding season being sufficiently long to permit ewes mated early in the season to lamb well before its end. Provided then that the lactation anoestrum, the length of which appears to vary according to the stage of the breeding season, does not run into the true anoestrum the ewes can mate and conceive again while lactating.

The onset of the breeding season is preceded by an ovulation without heat—' silent heat '. The evocation of heat with ovulation appears dependent on the presence of a waning corpus luteum.

Seasonal variation in the reproductive capacity of the ram is evident but is not as marked as in the ewe.

The literature on the dioestrus cycle, ovulation, fertilization, attachment and subsequent development of the embryo and foetus is reviewed. Very loose attachment to the cotyledons occurs at about 11 days after ovulation, which attachment remains loose up to the 30th day. Full placentation is not completed until the middle of pregnancy.

Embryonic mortality within the first 21 days accounts for an appreciable number of the ova fertilized. While the number of ova shed is probably the main factor controlling the number of lambs born, this mortality must be considered.

The use of gonadotrophins in anoestrum to obtain early pregnancies is fully discussed and the literature reviewed. While, in general, results have been disappointing there appears to be a definite pattern of behaviour depending on the state of the ovaries at the time of injection.

An interesting report on the use of pregnant mare's serum (P.M.S.) in inducing fertile matings shortly after parturition within the breeding season is discussed. If this can be confirmed it may be of value in obtaining two pregnancies within a year.

The subcutaneous injection of 500 i.u. of P.M.S. 12 days after the preceding oestrus will result in multiple ovulations at the ensuing heat period 4 or 5 days later. However, the individual response to any given level of P.M.S. is extremely variable, from two to nine ovulations having been observed following 500 i.u. Mating at this oestrus results in a high proportion of fertilizations and attachments. Subsequent embryonic mortality within the first 21 days following ovulation results in a reduction in the number of embryos surviving to two or three, occasionally four and rarely five or six. Up to four live young have been obtained at Cambridge and five in Russia. The number of lambs born in a small group of Suffolk ewes treated at Cambridge was greater than in the control group. However, some were born dead and the number weaned was similar in both groups.

There appear to be breed differences in the number of embryos surviving the first 3 weeks of pregnancy following such P.M.S. treatment, probably due to differences in uterine environment.

Overstimulation with gonadotrophins results in accelerated tubal transport of the ova, with lack of fertilization and complete failure to attach.

Taking a long-term view, increase in prolificacy can probably be best obtained by selection for a long breeding season and for multiple births. In most breeds there is sufficient variation in these characteristics to offer considerable hope of success.

OTHER PAPERS

HAMMOND, J. **Some Uses of A.I. in Cattle Production.** *Zootechnia (Madrid).* 1952, **1,** 14–18.

1124* HAMMOND, J. **Recent Developments in Animal Husbandry.** *Country Life.* 26th Sept., 1952.

PLANT BREEDING AND GENETICS

BELL, G. D. H. & LUPTON, F. G. H.

Yellow Rust in Wheat. Its Significance in Wheat Cultivation and Breeding in England.
Agriculture : J. Minist. Agric. 1952, **58,** 752–76.

Attention is drawn to the dangers of cultivating continental wheat varieties which are susceptible to yellow rust (*Puccinia glumarum*); it is emphasized that use of resistant varieties offers the only effective means of controlling the disease. An account is given of tests of the seedling reactions of varieties and hybrids to different races, recently carried out at the Cambridge Plant Breeding Institute. Seedlings showing resistance have been found to remain resistant at all later stages of development. The rust reactions of F_2 hybrid populations and of their parents have proved to be closely related ; the genetic basis of reaction to yellow rust is not however simple.

1102* Cooper, J. P. & Howard, H. W.

The Chromosome Numbers of Seedlings from the Cross *Solanum demissum* × *tuberosum* **Backcrossed by** *S. tuberosum*.

J. Genet. 1952, **50**, 511–21.

In breeding for resistance to blight (*Phytophthora infestans*) the wild Mexican potato *S. demissum* is used as a source of blight-resistance. It has a chromosome number of $2n=72$ as compared with $2n=48$ in *S. tuberosum*, the cultivated potato. The chromosome numbers of seedlings in the second, third and fourth backcross by *S. tuberosum* generations were found to range from $2n=54$ to $2n=48$. The genetics of blight resistance were also studied. The material contained 2 genes, one giving resistance to the B and A strains of blight and another resistance to the C and A strains. In many families there was a deficiency of seedlings with the gene for resistance to the B and A strains.

1107* Fyfe, J. L. & Bailey, N. T. J.

Plant Breeding Studies in Leguminous Forage Crops. I. Natural Cross-Breeding in Winter Beans.

J. Agric .Sci. 1951, **41**, 371–8.

If a crop varies in respect to a character which shows simple Mendelian inheritance then it is possible to estimate the proportion of cross-fertilization within the crop from the data obtained by (i) drawing plants from the crop and scoring them in respect of the character, then (ii) growing their separate progenies and scoring them.

Maximum likelihood expressions are given for the estimation of p and $f\{=(1-\alpha)/(1+\alpha)\}$ from the genotypic classification of the parents and from the phenotypic classification of the progenies; where p is the gametic frequency of the dominant allel and α is the proportion of fertilizations in which the pollen is equally likely to come from any plant in the population.

When the above expressions are applied to a case in winter beans, in which the parent plants were selected for high yield it is found that the different estimates of p agree, but those of f do not.

The precision of the estimates is improved by making a joint maximum likelihood estimation of the parameters, assuming a common value of p.

The conclusions reached are (i) that the parent plants were very probably all cross-bred plants; (ii) that when the rate of survival was comparable to that occurring in an ordinary crop, $31{\cdot}2\pm5{\cdot}3\%$ of their offspring were cross-bred; (iii) that under more severe conditions, with a lower survival rate, a higher estimate of $48{\cdot}5\pm5{\cdot}7\%$ was obtained.

Since winter beans stand about midway between the extremes of cross-and self-fertilizing crops, and since there is evidence of greater vigour in cross-bred beans, selection procedures whose final product is more inbred than commercial crops may suffer a corresponding handicap.

The class of crops which are propagated by seed, and have substantial proportions of both self-and cross-fertilization appears to need more critical study than it has hitherto received. Attention is drawn to the advantages of the foregoing method of estimating the proportion of cross-fertilization.

1117* Howard, H. W.

Autotetraploid Green Watercress.

J. Hort. Sci. 1952, **27**, 273–77.

A tetraploid green watercress with a chromosome number of 64 was made by colchicine treatment of a commercial stock of green cress which has a chromosome number of 32. This doubling of chromosome number produces a plant with broader and thicker leaflets which, it is suggested, is a valuable feature for a salad plant. It is not, however, yet known how the new type with the doubled chromosome number will compare for yield with the original stock. Other possibilities in watercress breeding by the use of colchicine for chromosome doubling are discussed.

1093* Howard, H. W.

A-4 Green Cress.

N.F.U. Watercress Br. News Sheet. 1951, **13** (55), 28.

A-4 is a tetraploid produced by doubling the chromosome number of a normal stock of green cress. Growers are offered a small number of plants for building up stocks and for testing under the rather special conditions of commercial watercress beds.

Howard, H. W.

Crops and Plant Breeding.

J. R. Agric. Sci. 1951, **112**, 84–95.

The main headings in this annual review article were :—Plant Breeding Problems ; Wheat ; Rye ; Oats, Qualitative Control of Seeds ; Potatoes ; Herbage Legumes ; Grasses ; and Selective Weed Control.

HOWARD, H. W. & LYON, A. G.

Biological Flora of the British Isles : *Nasturtium officinale* R. Br. and *N. microphyllum* Boenningh ex. Rchb.

J. Ecol. 1952, **40**, 228–45.

A summary of our knowledge of watercress as a wild plant in the British Isles. There is a list of 66 references.

1091* HOWARD, H. W. & LYON, A. G.

Distribution of the British Watercress Species.

Watsonia. 1951, **2**, 91–2.

Further records are given for the vice-comital distribution in Great Britain of *Nasturtium officinale*, *N. microphyllum* and the hybrid *N. microphyllum* × *officinale*.

1103* HOWARD, H. W. & SWAMINATHAN, M. S.

Species Differentiation in the Section Tuberarium of Solanum with Particular Reference to the Use of Interspecific Hybridisation in Breeding.

Euphytica. 1952, **1**, 20–28.

It is suggested that there may exist small structural differences between the chromosomes of the genoms of the tuber-bearing *Solanum* species.

For the diploid (2n = 24) species, the best evidence for such small structural differences is obtained from a comparative study of meiosis in amphidiploids and autotetraploids.

The problem is more complex in the tetraploid and hexaploid species. Studies of meiosis in F_1 *S. demissum* × *S. tuberosum*, F_1 *S. demissum* × *S. rybinii* and the triple hybrid [(*S. demissum* × *S. rybinii*) × *S. tuberosum*] suggest that the single genom of *S. rybinii*, the two genoms of *S. tuberosum* and the three genoms of *S. demissum* are similar enough for their chromosomes to form bivalents.

From the results of multiple crosses, it appears that species which cannot be crossed directly with *S. tuberosum* may not have genoms very different from those found in that species.

The importance of all these studies to problems of potato breeding involving interspecific hybridisation are considered.

1126* SACHS, L.

Chromosome Mosaics in Experimental Amphiploids in the *Triticinae*.

Heredity. 1952, **6**, 157–70.

Chromosome mosaics at meiosis arise in the anthers of 19 out of 24 new amphiploids in *Triticum*, *Aegilops*, and *Agropyron*.

The mosaics occurred in all the 8*x*, in some of the 6*x*, but not in a 10*x* amphiploid.

The anthers with mosaics contain at meiosis a mixture of cells with complete amphiploid and various reduced aneuploid numbers.

37 reduced chromosome numbers, from 9 to 48, were found in the 8*x* amphiploids, and 24 reduced numbers, from 10 to 40, in the 6*x* amphiploids. 27 numbers at meiosis occurred in a single 8*x* plant, and 10 numbers at meiosis in a single 6*x* plant.

There was no relationship between the presence of mosaics and chromosome pairing in those cells which have retained a complete chromosome complement.

The reduced cells in mosaic plants represent at meiosis an almost random assortment of chromosomes. Mosaics probably arise by gene-controlled spindle abnormalities just before meiosis.

Plants bred true for mosaic formation. Moreover, reduced cells in mosaic plants can function as gametes. Their progeny can again produce mosaics. A range of chromosome numbers can thus be derived from the same amphiploid.

OTHER PAPERS

1098* BELL, G. D. H. **Historical Review of Cereal Varieties and Breeding.** *Woodheads Seeds Ltd., 150th Anniv. Brochure*, 1951. Pp. 22–33.

Commonwealth Potato Collection Report, 1950–51. *Annu. Rep. Exec. Counc. Comm. Agric. Bur.* 1950-51, **22**, 32–4.

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HAWKES, J. G. **Cinco Conferencias sobre el Mejoramiento de la Papa.** *Bol. Tec. Inst. Nac. Agric. Maracay, Venezuela.* 1 (1951).

1104* HUDSON, P. S. **Genetica e Agricultura nella Organizzazione Internazionale.** *Atti Convegno Genet. Agrar., Rieti*, 1950. Pp. 44–52.

SOILS AND MANURES (including Meteorology)

1092* EDEN, A., ALDERMAN, G., BAKER, C. J. L., NICHOLSON, H. H. & FIRTH, D. H.

The Effect of Ground Water-level upon Productivity and Composition of Fenland Grass.

J. Agric. Sci. 1951, **41**, 191–202.

Studies were made of the effects of varying ground water-levels upon the productivity and composition of Italian Ryegrass grown on a calcareous light peat in the Fenland area. Six cuts were taken throughout the season at 3 to 4-weekly intervals.

High ground water-level (approximately 15 in. below ground surface) had a very deleterious effect on the total yield of fresh grass and of dry matter. Yields were little more than half of those obtained at medium and low water-levels (24 and 38 in. below ground surface, respectively).

High water-level apparently interfered with nitrogen metabolism in the soil, and considerably lower percentages of crude protein were found in the grass growing on the high water-level plots than at the other levels. On the other hand, the percentage of crude fibre remained fairly constant for all levels of ground water.

High water-level also had a depressing effect on the percentage of potassium, magnesium and chlorine in the grass. It had no obvious effect upon the calcium and phosphorus levels in the plants. The silica content of the grass rose steadily as the season advanced, this being most marked on the high water-level plots.

Physical examination of typical plants showed the effect of the various ground water-levels upon the development of the root systems, with consequent effect upon the chemical composition of the grass.

The composition of hay and aftermath showed similar changes to those reported for the green herbage.

The findings are discussed in relation to grass-drying policies in Fenland areas.

1101* Rider, N. E.

The Effect of a Hedge on the Flow of Air.
Quart. J. R. Met. Soc. 1952, **78**, 97–101.

Experiments are described in which the horizontal wind speed at three heights up to 2 m is measured at various distances up and down wind from a dense hedge 1.68 m high on occasions with wind directions approximately normal to the hedge. The results show that the hedge begins to exert an influence on the wind speed at 2 m at a distance equivalent to approximately 15 hedge heights upwind, and that downwind its influence extends to a distance approximately equivalent to 60 hedge heights. At the two lower heights of wind-speed measurement the range over which the hedge has an effect is smaller. Diagrams are constructed to show the decrease in wind speed at the various heights within the distance range mentioned above.

STATISTICS

1122* Wishart, J.

Biological Experimentation.
Incorp. Statist. 1951, **2**, 21–29.

This is the substance of an invited lecture given to the Association of Incorporated Statisticians on the occasion of their annual conference at Oxford in 1951. It consists of an expository account of the more recent developments of small sample theory in mathematical statistics, with particular reference to their application to the design and conduct of experiments in the biological sciences.

1123* Wishart, J.

Moment Coefficients of the k-Statistics in Samples from a Finite Population.
Biometrika. 1952, **39**, 1–13.

A landmark in the similar problem to this for samples from an infinite population was reached in 1929, when R. A. Fisher, defined the k-statistics, and showed how the cumulants of the simultaneous distribution of such statistics could be worked out, both algebraically and combinatorially. Since then, the corresponding problem for samples from a finite population has been studied. In particular Tukey introduced in 1950 a generalized (multiple-suffix) k-statistic which has proved to be useful in simplifying the presentation of formulae for the moment coefficients. The present author has studied the subject systematically, has worked out a series of formulae for expressing powers and products of the generalised k-statistics as linear functions of these same statistics, and then by means of these formulae has been able to work out a considerable number of the required moment coefficients. In some cases completely general formulae are available. In the course of this work it emerged that the combinatorial method of R. A. Fisher was fundamentally associated with the first stage in the work, before any expectations were calculated, and this not only assisted materially in the production of the formulae, but also threw considerable light on the method for infinite as well as for finite populations.

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Eagle. 1952, **55** (240–1), 89–94.

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